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Introduction to the Livestock Analysis Model

Population Model and Methane Emissions Model

This paper presents a brief summary of the Livestock Analysis Model (LAM) Version 1.01 developed by ICF Incorporated. This initial version of the model is being made available for review and comment. Please provide your comments to the address listed below.

Purpose

The purpose of the Livestock Analysis Model (LAM) is to provide a tool for:

- Characterizing cattle and buffalo populations driven by the supply and demand for livestock products: milk, meat, and draft power.
- Evaluating the impact of changes in production characteristics on the population of cattle and buffalo.
- Evaluating baseline and future methane emissions from cattle and buffalo populations.

Overview of Main Model Elements

LAM is divided into four main elements as follows:

1. Production Targets. Target levels of production are set for milk, meat, and draft power. These production targets may be sub-divided into the following sectors: up to four separate milk herds, two separate draft power herds, and one meat producing herd. LAM links the sectors together so that the production of multiple products from one herd (e.g., both milk and meat) affects the targets for the other herds in all sectors.
2. Production Characteristics. This portion of the model is used to define the production characteristics of each herd, such as the rate of milk production and mortality rates. LAM uses these production characteristics to generate the size and composition of each sector and the overall population of cattle and buffalo.
3. Methane Characteristics. This portion of the model is used to define the characteristics that affect methane emissions rates. The data required and the method used is based on the IPCC/OECD Emissions Inventory Guidelines (1994).
4. Results. This portion of the model presents the results of the calculations, including descriptions of the livestock populations by sector and methane emissions.

Using LAM

LAM is designed to be used as an assessment tool in the following manner:

- Calibration. Using data on production levels and animal characteristics for a recent historical year (e.g., 1990), simulate the population and productivity of the relevant livestock. The inputs should be checked and verified to ensure that the model produces a simulation of the livestock population that is consistent with the data available for the historical year.

- Baseline. Using projected production levels and animal characteristics for a future year (e.g., 2000), simulate a baseline of the expected livestock population and methane emissions.
- Simulated Intervention. To simulate the implications of an intervention, first define how the intervention would affect production targets, production characteristics, or methane characteristics. For example, providing improved nutrients to rural dairy cows would increase milk production per lactation, reduce the inter-calving interval between lactations, and increase feed digestibility. The new characteristics are then entered into LAM to simulate the population and methane emissions that would result from the implementation of the intervention.
- Impact. The impact of the intervention is estimated as the difference between the baseline simulation and the intervention simulation.

Caveats

LAM implements an equilibrium population model based on the approach in Hallam (1983). The model cannot simulate how the livestock population will evolve over time as its characteristics change. Therefore, the year of the assessment must be far enough in the future to allow the livestock population to adjust to its changed characteristics. The model is not suitable for simulating livestock populations with rapidly changing characteristics.

The estimates produced by LAM are only as good as the inputs used to describe the livestock populations. Care must be taken in developing and using the necessary data and checking the data using a calibration step as discussed above.

Comments

LAM is currently under development, and all comments are welcome regarding its usefulness and suitability as an assessment tool. Please provide comments to:

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Using the Livestock Analysis Model

System Requirements

LAM was developed using Quattro Pro 5.0 for Windows and Excel 5.0 for Windows. To run LAM, one of the versions of either Quattro Pro or Excel, or later, is required. The Quattro Pro and Excel versions are virtually identical, and are operated in essentially the same manner.

Copy the Quattro Pro or Excel Notebook File

The Quattro Pro notebook file is LAM_101.WB1. The Excel notebook file is LAM_101.XLS. Copy this file from the diskette provided, and keep the diskette in a separate place.

Open the File to Start

To use LAM, start the appropriate application (Quattro Pro or Excel for Windows) and open the LAM file. The model has been set to only allow entry in those cells in which the user can provide input.

Setting Production Targets

Exhibit 1 displays the screen for setting production targets. First, set the overall production targets for milk, meat, and draft power (measured as the number of head of draft animals). Then, spread the production targets into the various possible sectors using percentages (i.e., 0.50 would be 50%). You may enter a brief name for each sector. The following sectors may be used:

- Milk Sectors: Four separate milk sectors may be defined, each with its own target and characteristics. For example, separate sectors may be defined for: peri-urban cows; rural cows; peri-urban buffalo; and rural buffalo.
- Draft Sectors: Two separate draft sectors may be defined, each with its own target and characteristics. For example, separate sectors may be defined for: bullocks and buffalo.
- Meat Sector: A single meat producing sector may be defined.

The overall targets are initially spread among the relevant sectors. For example, the milk target is spread among the milk sectors. However, all sectors can contribute to the production of all three products, depending on the production characteristics defined for each.

Exhibit 1: Setting Targets

In this example, milk and meat production targets are set, and the draft target is zero. The milk target is allocated to a single sector: Milk_1, with the label entered by the user as Urban. The meat target is allocated to the single meat sector. Because we have set the total draft production target to zero, it is not necessary to change any draft variables in the model. For example, the screen below shows draft production as split between two sectors, but each sector is producing 50% of zero. LAM will calculate a herd size and methane emissions of zero for the draft sector.

Set Production Targets by Livestock Sector and Product

Product	**Target**
Milk Production (1000 tons/yr)	68,000.0
Draft Production (1000 Head)	0.0
Meat Production (1000 tons/yr)	9,000.0

Distribution of Production Targets by Sector
(Each Row Must Equal 100%)

	Milk_1	Milk_2	Milk_3	Milk_4	Draft_1	Draft_2	Meat	Total
Sector Label (Optional) ==>	Urban	Rural	Blank	Blank	Temp	Tropic	All	
Milk Production (1000 tons)	100%	0%	0%	0%	NA	NA	NA	100%
Draft Production (1000 Head)	NA	NA	NA	NA	50%	50%	NA	100%
Meat Production (1000 tons)	NA	NA	NA	NA	NA	NA	100%	100%

Production Characteristics

Exhibit 2 displays the screen for entering the production characteristics of each livestock sector. These characteristics are divided into the following categories:

- **Cows: Milk Production:** This section is used to define the milk production characteristics. The percent of milk that is produced for target is the milk used to meet the milk production target for human consumption. In this example, only cows in the four milk sectors are listed as producing milk for humans to meet the target. In fact, all sectors can produce milk for humans.
- **Bulls: Ratio to Cows:** This section lists the number of bulls per cow for the milk and meat sectors. This ratio is not needed for the draft sector, which is driven (in part) by the need to produce bulls for draft power.
- **Draft Power Definitions:** This section defines the animals that can be used as draft power. In this example, 95% of the adult males are usable as draft and 50% of the non-bred adult females are usable as draft in the draft sectors only. "Wet" (lactating) bred females and "dry" (non-lactating) bred females may also be considered for draft use, but are set to zero in this example. Young animals (non-adults) are not counted as draft animals. Although this example only defines animals in the draft herd as providing draft power, the relevant animals in all sectors can be defined to provide draft power.

Exhibit 2: Production Characteristics

	Milk_1 Urban	Milk_2 Rural	Milk_3 Blank	Milk_4 Blank	Draft_1 Temp	Draft_2 Tropic	Meat All
Cows: Milk Production							
Milk per lactation (tons)	6.80	6.80	6.80	6.80	0.90	0.90	1.74
Length of lactation (days)	305	305	305	305	200	200	200
Intercalving interval (days)	365	365	365	365	600	600	365
Percent of Cows that are Bred	100.0%	100.0%	100.0%	100.0%	75.0%	50.0%	90.0%
Percent of milk produced for target	100.0%	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%
Bulls: Ratio to Cows							
Bulls per cow	0.02	0.02	0.02	0.02	N/A	N/A	0.07
Draft Power Definitions							
Pct adult males usable as draft	0%	0%	0%	0%	95%	95%	0%
Pct non-bred females usable as daft	0%	0%	0%	0%	50%	50%	0%
Pct "wet" females usable as daft	0%	0%	0%	0%	0%	0%	0%
Pct "dry" females usable as daft	0%	0%	0%	0%	0%	0%	0%
Meat Production Characteristics							
Adult Male carcass wt (1000 kg)	0.300	0.300	0.300	0.300	0.180	0.180	0.300
Adult Female carcass wt (1000 kg)	0.250	0.250	0.250	0.250	0.150	0.150	0.200
Slaughter male carcass weight (1000 kg)	NA	NA	NA	NA	NA	NA	0.300
Slaughter female carcass weight (1000kg)	NA	NA	NA	NA	NA	NA	0.250
Transfer Young to Meat Sector? (1=Yes)	1	1	1	1	1	1	NA
Maximum Years in the Herd: Adults, Replacements, Young							
Yrs in herd -- adult males (Max = 10)	8	8	8	8	10	10	8
Yrs in herd -- adult females (Max = 10)	5	5	5	5	10	10	8
Yrs in herd -- repl males (Max = 4)	1	1	1	1	4	4	1
Yrs in herd -- repl females (Max = 4)	1	1	1	1	4	4	1
Yrs in herd -- young males (Max = 4)	1	1	1	1	1	1	1
Yrs in herd -- young females (Max = 4)	1	1	1	1	1	1	1
Yrs to slaughter for slaughterstk (Max = 4)	NA	NA	NA	NA	NA	NA	0.4
Annual Mortality Rates							
Annual death rate -- adult males	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Annual death rate -- adult females	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Annual death rate -- repl males	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Annual death rate -- repl females	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Annual death rate -- young males	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
Annual death rate -- young females	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
Adult Male Cull Rate	2.0%	2.0%	2.0%	2.0%	0.0%	0.0%	10.0%
Adult Female Cull Rate	30.0%	35.0%	35.0%	35.0%	0.0%	0.0%	10.0%
Annual death rate -- slaughter stock	NA	NA	NA	NA	NA	NA	1.0%

- **Meat Production Characteristics:** This section lists the carcass weights of the relevant animal types at slaughter. Adult males and females may be slaughtered in all sectors, and young animals grown specifically for meat production may be slaughtered in the meat sector. The adult animals are counted toward the meat target when they are culled and when they reach their maximum age. Animals lost due to other causes of death are not counted toward the meat target.

  In addition to the carcass weight, this section is used to indicate if "excess" young from a given sector are "transferred" to the meat sector for use in meeting the meat production targets. For example, it is often the case that the dairy sector produces more male calves than are needed in the dairy sector. These "excess calves" may be transferred to the meat sector and grown for slaughter. Transferring these excess young to the meat industry is indicated by a putting a one for this input. Putting a zero for this input causes the number of excess calves to be estimated in the dairy sector, but no additional computations are made for them. These calves, for example, may be exported or may be used to meet a deficiency in calves in another sector, such as the draft sector.
- **Maximum Years in the Herd: Adults, Replacements, and Young:** This section defines the ages of the three animal types. By grouping the animals by level of development, the model can better represent animal populations in different areas of the world, where animals may mature at different rates. The LAM user can define the age categories by entering the "years in herd" for each. Generally, "young" animals may not be fully weaned and often experience rapid growth, "replacements" are weaned animals that are not fully mature and do not produce much draft or milk, and "adults" are fully mature animals. In this example, the animals grow relatively quickly, so that they are considered as "young" for one year and "replacement" for one year. After they are replacements, they are considered adults. The number of years it takes to grow to slaughter weight (following being young) is also listed. In this example, the meat animals are slaughtered at 1.4 years of age (1.0 years as young, and 0.4 years being grown for slaughter). The LAM user will be able to specify the methane emission characteristics for each of the age groups on the methane characteristics sheet.
- **Annual Mortality Rates:** The annual mortality rates are used to simulate the loss of animals due to reasons other than for slaughter. Annual death rates are given for each animal type. These rates are considered when simulating the size of the population needed to meet the production targets. Additionally, cull rates for male and female adults are listed. The culled animals contribute to the meat targets, while the loss due to death from other causes does not.

Characteristics for Estimating Methane Emissions Factors

Exhibit 3 presents the data required to estimate methane emissions. Most of the information needed to estimate emissions is derived from the production characteristics, such as: milk production; percent bred; and definition as a draft animal. Several key inputs must be provided for each animal type in each sector. The following is required:

- **Weight:** The average annual weight for the animal type is needed. This weight is a key input for estimating emissions. It is the principal driving factor for estimating feed intake, and is also used to estimate weight gain. Care must be taken to ensure that the weights used in this input table are consistent with the carcass weights used in the Production Characteristics input table.
- **Feeding Situation:** The feeding situations are defined in LAM and the IPCC/OECD Emissions Inventory Guidelines (1994). In this example, the dairy animals are all stall fed. Other possible values are pasture/range fed and grazing over very large areas. These values are entered into LAM using a number code, which is shown in Exhibit 4.

- **Feed Digestibility.** The feed digestibility also has an important impact on the methane emissions estimate. Typical values range from 50 percent for poor quality rangelands to over 75 percent for grain-fed slaughter animals. Typical values will be in the range of 60 to 65 percent for most animal types.
- **Methane Conversion Factor:** The methane conversion factor defines the portion of gross energy intake that will be converted to methane. The IPCC/OECD Emissions Inventory Guidelines (1994) provide "standard assumptions" to use for this factor. A value of 6.0 percent is commonly used for most well fed animals. Young animals, who nurse for a portion of the year, will generally have a lower value, such as the 3.0 percent shown in the example. These values are entered into LAM using a number code, which is shown in Exhibit 4.

Exhibit 3: Characteristics for Estimating Methane Emissions Factors

Sector	Sector Name	Animal Type	Methane Emissions (kg/hd/yr)	Weight (kg)	Feeding Situation (1-3 above)	Feeding Situation Selected	Feed Digest (%)	Methane Conversion (1-8 above)	Methane Conversion Selected
Milk_1	Urban	Adult Males	54.5	650	1	Stall Fed	60	1	6.0%
Milk_1	Urban	Adult Females	114.8	550	1	Stall Fed	65	1	6.0%
Milk_1	Urban	Repl Males	64.0	350	1	Stall Fed	60	1	6.0%
Milk_1	Urban	Repl Females	53.0	300	1	Stall Fed	60	1	6.0%
Milk_1	Urban	Young Males	14.5	200	1	Stall Fed	65	6	3.0%
Milk_1	Urban	Young Females	12.9	200	1	Stall Fed	65	6	3.0%
Milk_2	Rural	Adult Males	54.5	650	1	Stall Fed	60	1	6.0%
Milk_2	Rural	Adult Females	114.8	550	1	Stall Fed	65	1	6.0%
Milk_2	Rural	Repl Males	64.0	350	1	Stall Fed	60	1	6.0%
Milk_2	Rural	Repl Females	53.0	300	1	Stall Fed	60	1	6.0%
Milk_2	Rural	Young Males	14.5	200	1	Stall Fed	65	6	3.0%
Milk_2	Rural	Young Females	12.9	200	1	Stall Fed	65	6	3.0%
Sectors Milk_3 and Milk_4 are omitted from this exhibit.									
Draft_1	Temp	Adult Males	59.4	400	1	Stall Fed	60	1	6.0%
Draft_1	Temp	Adult Females	44.5	300	1	Stall Fed	60	1	6.0%
Draft_1	Temp	Repl Males	29.3	250	1	Stall Fed	60	1	6.0%
Draft_1	Temp	Repl Females	20.3	150	1	Stall Fed	60	1	6.0%
Draft_1	Temp	Young Males	10.6	100	1	Stall Fed	60	6	3.0%
Draft_1	Temp	Young Females	7.1	75	1	Stall Fed	60	6	3.0%
Draft_2	Tropic	Adult Males	59.4	400	1	Stall Fed	60	1	6.0%
Draft_2	Tropic	Adult Females	46.3	300	1	Stall Fed	60	1	6.0%
Draft_2	Tropic	Repl Males	29.3	250	1	Stall Fed	60	1	6.0%
Draft_2	Tropic	Repl Females	20.3	150	1	Stall Fed	60	1	6.0%
Draft_2	Tropic	Young Males	10.6	100	1	Stall Fed	60	6	3.0%
Draft_2	Tropic	Young Females	7.1	75	1	Stall Fed	60	6	3.0%
Meat	All	Adult Males	63.7	650	2	Pasture/Range	60	1	6.0%
Meat	All	Adult Females	71.0	450	2	Pasture/Range	60	1	6.0%
Meat	All	Repl Males	69.3	330	2	Pasture/Range	60	1	6.0%
Meat	All	Repl Females	49.0	330	2	Pasture/Range	60	1	6.0%
Meat	All	Young Males	17.7	200	2	Pasture/Range	60	6	3.0%
Meat	All	Young Females	17.7	200	2	Pasture/Range	60	6	3.0%
Meat	All	Male Slaught	26.5	550	1	Stall Fed	75	5	3.5%
Meat	All	Female Slaught	22.2	500	1	Stall Fed	75	5	3.5%

Note: The methane emissions value is calculated in the model. The values for "Methane Conversion Selected" can be changed by editing the methane conversion factors table on the Methane Characteristics page. Sectors Milk_3 and Milk_4 are omitted from this exhibit.

Exhibit 4: Feeding Situation and Methane Conversion Number Codes

Summary Inputs and Coefficients		
Feed Table: Add'l NE required to get feed		
1	Stall Fed	0.0%
2	Pasture/Range	17.0%
3	Large Areas	37.0%
Methane Table: Assumed methane conversion of GE		
1	Good Quality Feed	6.0%
2	Medium Quality Feed	6.5%
3	Poor Quality Feed	7.0%
4	Very Poor Quality	7.5%
5	Feedlot	3.5%
6	Young (Nursed)	3.0%
7	Milk Fed	0.0%
8	User Defined	6.0%

The number to the left of the appropriate feeding situation or methane conversion factor is entered into the Characteristics for Estimating Methane Emissions Factors Table for each animal type. If needed, additional methane conversion rates can be defined.

Results

Exhibit 5 shows the results screen of the model. The screen is divided into five sections. The first section shows that the production targets were met. Additionally, the methane emissions estimate is shown.

The second section shows the results by sector. As shown in this example, all the milk is produced in the milk sector. This sector also produces some amount of meat, principally from the cows that are culled. The remainder of the meat is produced in the meat sector. The methane emissions are also reported by sector in the last row. Note that the draft production is zero, resulting in a draft emissions of zero.

The third section of the results shows the population and production in each sector in detail. Each animal type is listed. In this example, the Milk Sector has 18.6 million head, while the Meat Sector has 85.3 million head. Because no draft power is produced, the draft sector has no herd.

The fourth section of the report shows emissions per unit of product produced. The emissions from each of the milk sectors is divided by the production in each sector to get the estimate for each. Similar analyses are done to estimate emissions per unit of draft power and emissions per unit of meat produced.

The final section of the results shows methane emissions by animal type within each sector. In this example, the emissions from the adult cows account for the majority of the total emissions.

References

Hallam, David (1983), Livestock Development Planning: a Quantitative Framework, Centre for Agricultural Strategy, University of Reading, Reading, U.K., May 1993.

IPCC/OECD (Intergovernmental Panel on Climate Change and Organization of Economic Cooperation and Development) (1994), Greenhouse Gas Inventory Reference Manual, IPCC Draft Guidelines for National Greenhouse Gas Inventories.

Exhibit 5: Results

Product	Result	Target
Milk Production (1000 tons/yr)	68,000.0	68,000.0
Draft Production (1000 Head)	0.0	0.0
Meat Production (1000 tons/yr)	9,000.0	9,000.0
Methane Emissions (tons/yr)	5,028,392	NA

Results by Sector	Milk_1 Urban	Milk_2 Rural	Milk_3 Blank	Milk_4 Blank	Draft_1 Temp	Draft_2 Tropic	Meat All	Total
Milk Production (1000 tons/yr)	68,000	0	0	0	0	0	0	68,000
Draft Production (1000 Head)	0	0	0	0	0	0	0	0
Meat Production (1000 tons/yr)	959	0	0	0	0	0	8,041	9,000
Methane Emissions (tons/yr)	1,430,359	0	0	0	0	0	3,598,033	5,028,392

Detailed Results by Sector	Milk_1 Urban	Milk_2 Rural	Milk_3 Blank	Milk_4 Blank	Draft_1 Temp	Draft_2 Tropic	Meat All	Total
Total Herd (1000)	18,600	0	0	0	0	0	85,291	103,891
Bulls (1000)	200	0	0	0	0	0	2,121	2,321
Cows (1000)	9,994	0	0	0	0	0	31,818	41,812
Male Replacements (1000)	29	0	0	0	0	0	421	450
Female Replacements (1000)	4,048	0	0	0	0	0	6,312	10,360
Male Young (1000)	31	0	0	0	0	0	19,284	19,315
Female Young (1000)	4,298	0	0	0	0	0	15,018	19,315
Male Slaughters (1000)	NA	NA	NA	NA	NA	NA	7,140	7,140
Female Slaughters (1000)	NA	NA	NA	NA	NA	NA	3,176	3,176
Extra Young - Male (1000)	0	0	0	0	0	0	0	0
Extra Young - Female (1000)	0	0	0	0	0	0	0	0
Milk (1000 tons/yr)	68,000	0	0	0	0	0	0	68,000
Meat (1000 tons/yr)	959	0	0	0	0	0	8,041	9,000
Draft Male (1000)	0	0	0	0	0	0	0	0
Draft Female (1000)	0	0	0	0	0	0	0	0
Total Draft (1000)	0	0	0	0	0	0	0	0

Emissions per unit product	Milk_1 Urban	Milk_2 Rural	Milk_3 Blank	Milk_4 Blank	Draft_1 Temp	Draft_2 Tropic	Meat All
CH4/Milk (g/kg)	21.03	0.00	0.00	0.00	NA	NA	NA
CH4/Draft (kg/Head)	NA	NA	NA	NA	0.00	0.00	NA
CH4/Meat (g/kg)	NA	NA	NA	NA	NA	NA	447.48

Detailed Emissions by Sector	Milk_1 Urban	Milk_2 Rural	Milk_3 Blank	Milk_4 Blank	Draft_1 Temp	Draft_2 Tropic	Meat All	Total
Total Herd (tons)	1,430,359	0	0	0	0	0	3,598,033	5,028,392
Bulls (tons)	10,890	0	0	0	0	0	135,219	146,110
Cows (tons)	1,146,996	0	0	0	0	0	2,257,593	3,404,589
Male Replacements (tons)	1,889	0	0	0	0	0	29,158	31,047
Female Replacements (tons)	214,521	0	0	0	0	0	309,402	523,922
Male Young (tons)	454	0	0	0	0	0	341,391	341,845
Female Young (tons)	55,609	0	0	0	0	0	265,861	321,470
Male Slaughters (tons)	NA	NA	NA	NA	NA	NA	188,905	188,905

Female Slaughters (tons)	NA	NA	NA	NA	NA	NA	70,504	70,504

LAM Tutorial: The Country of Mitocha

Introduction

This tutorial is intended to introduce new users to the LAM. A Case Study is presented using illustrative data for the hypothetical country of Mitocha.

Dorje, the Minister of Environment in Mitocha is considering establishing a dairy industry development program in the Topi Region of Mitocha. This program would be designed to promote economic development and improve milk production. As an additional benefit, the program may also reduce methane emissions. Minister Dorje has decided to use LAM to estimate what emissions reductions the program could achieve.

Calibration

To begin, Minister Dorje must calibrate the model to the current conditions in the Topi Region. First he gathered information about each sector of the livestock industry, including data on each animal category, their production levels and herd size. To gather this information, Minister Dorje contacted the Minister of Agriculture and several other livestock experts. They determined how to group animals based on management and production characteristics. The production levels of animals in each group, or sector, were determined. Using this detailed production data, Minister Dorje calculated the total current production levels for each sector and each industry in the Topi Region. Follow the instructions below to enter this information into the model:

What information is needed

Total Production Level:

LAM uses the total current or projected production levels of milk, meat, and draft to calculate herd size (draft production is the number of working adult animals). For the model calibration, we will enter the current total production levels that Minister Dorje calculated from the region's production sectors.

How to enter the information

- In the LAM **Targets Sheet**,
  - ⇒ Enter current production levels in the Production Target Table (see table below). The Topi Region currently produces 10,000 metric tons of milk, 1,500 metric tons of meat, and has 10,000 working draft animals.

Product	Target
Milk Production (1000 tons/yr)	10.0
Draft Production (1000 Head)	10.0
Meat Production (1000 tons/yr)	1.5

What information is needed

Distribution of Production by Sector:

When an industry is divided into different sectors, the total production level for each sector must be entered into LAM. LAM can recognize up to four separate milk herds, two separate draft power herds, and one meat producing herd, each with different production characteristics. The "distribution of production by sector" is the percentage of total production produced by that sector.

It is not necessary to use all of the columns provided for different sectors. For example, there are only 3 milk sectors in Topi Region, and LAM gives four columns. In this case, the fourth milk sector produces zero percent of the total milk production. If you enter zero for the sector in this table, LAM will calculate a herd of zero animals for that sector. Therefore, it is not necessary to enter or modify any other numbers in the model regarding that sector.

How to enter the information

⇒ Enter the distribution of production among the animal sectors. In the Topi Region, the dairy industry includes three sectors that have different production characteristics -- Urban, Rural Lowlands and Rural Hills. The Draft animals all fall in one sector, which we will label Buffalo. The animals raised specifically for meat also fall into one category, which we will call All. Enter the names for each sector and the proportion of total milk, draft, and meat production that comes from each sector (see table below). Enter a production percentage of zero for sector Milk_4 and Draft_2. Do not try to delete these columns in the LAM model.

Distribution of Production Targets by Sector
(Each Row Must Equal 100%)

	Milk_1	Milk_2	Milk_3	Milk_4	Draft_1	Draft_2	Meat	Total
Sector Label (Optional) ==>	Urban	Rural-Low	Rural-Hills	Blank	Buffalo	Blank	All	
Milk Production (1000 tons)	40%	30%	30%	0%	NA	NA	NA	100%
Draft Production (1000 Head)	NA	NA	NA	NA	100%	0%	NA	100%
Meat Production (1000 tons)	NA	NA	NA	NA	NA	NA	100%	100%

What information is needed

Milk Production:

The milk per lactation, length of lactation, intercalving interval, percent of cows bred, and percent milk produced for humans must be entered in LAM for each sector to determine the herd size and composition that would be able to supply the milk target production level. The milk per lactation and the time between calves (intercalving interval) are strongly influenced by health and nutrition and can have a large impact on total herd size.

How to enter the information

- Move to the **Production Characteristics Sheet** by clicking on the labeled button. On this sheet:

  ⇒ Enter the milk production data (see following table). Ignore the columns representing sectors with no production (Milk_4 and Draft_2). Note the differences in the three dairy sector characteristics. Also note that in Topi Region, 15% of the milk from buffalo goes to human consumption to meet the target production level.

	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All
Cows: Milk Production							
Milk per lactation (tons)	3.50	1.00	1.10	1.00	0.90	0.90	1.74
Length of lactation (days)	300	270	275	305	200	200	200
Intercalving interval (days)	450	660	650	365	600	600	365
Percent of Cows that are Bred	100.0%	100.0%	100.0%	100.0%	75.0%	50.0%	90.0%
Percent of milk produced for target	100.0%	100.0%	100.0%	100.0%	15.0%	0.0%	0.0%

Note: A non-zero value for "Milk per lactation" must be entered for each sector, even if that sector has a milk target of zero.

What information is needed

Bull to Cow Ratio and Draft Power Definitions:

LAM uses the ratio of bulls to cows in each sector to determine how many bulls are in the herd. In many regions males in the dairy sector are used as draft animals, substantially decreasing the herd size of the draft sector.

How to enter the information

⇒ Enter the Bull to Cow Ratio and Draft Power Definitions (see table below). Ignore any columns representing sectors with no production. Note the use of bulls from other sectors as draft animals.

	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All
Bulls: Ratio to Cows							
Bulls per cow	0.1	0.1	0.1	0.1	N/A	N/A	0.07
Draft Power Definitions							
Pct adult males usable as draft	90%	90%	90%	90%	95%	95%	90%
Pct non-bred females usable as daft	0%	0%	0%	0%	50%	50%	0%
Pct "wet" females usable as daft	0%	0%	0%	0%	0%	0%	0%
Pct "dry" females usable as daft	0%	0%	0%	0%	0%	0%	0%

What information is needed

Meat Production Characteristics:

LAM uses information about the carcass weight to determine the size of the meat sector herd required to fulfill meat production target levels. An animal's carcass weight is significantly less than an animal's live weight. Minister Dorje consulted with slaughter facilities to determine the carcass weights of animals from each sector.

Excess young born in dairy or draft sectors are often transferred into the meat industry to be raised. This affects the meat herd size needed to achieve target production levels.

How to enter the information

⇒ Enter the Meat Production Characteristics (see table below). Ignore any columns representing sectors with no production. Note the different carcass weights for the dairy and meat sectors. Verify that the excess young from other sectors are transferred to the meat sector (indicated by the number 1 in the last row).

	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All
Meat Production Characteristics							
Adult Male carcass wt (1000 kg)	0.200	0.180	0.180	0.180	0.180	0.180	0.180
Adult Female carcass wt (1000 kg)	0.160	0.150	0.150	0.150	0.150	0.150	0.150
Slaughter male carcass weight (1000 kg)	N/A	N/A	N/A	N/A	N/A	N/A	0.200
Slaughter female carcass weight (1000kg)	N/A	N/A	N/A	N/A	N/A	N/A	0.180
Transfer Young to Meat Sector? (1=Yes)	1	1	1	1	1	1	NA

What information is needed

Maximum Years in the Herd:

Years in the herd expresses the rate of growth in each sector. The higher the number of years spent in each development stage, the slower the growth of the animal.

After the "young" period, some animals are prepared and fed specifically for slaughter, sometimes in feedlots. The "years to slaughter for slaughterstock" number indicates the length of time used to prepare the animals for slaughter.

How to enter the information

⇒ Enter the maximum years in the herd (see following table). Ignore any columns representing sectors with no production. Note the differences in the dairy sector characteristics. Note the one year slaughterstock preparation time to slaughter.

	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All
Maximum Years in the Herd: Adults, Replacements, Young							
Yrs in herd -- adult males (Max = 10)	8	8	8	8	10	10	8
Yrs in herd -- adult females (Max = 10)	8	8	8	8	10	10	8
Yrs in herd -- repl males (Max = 4)	2	2	2	2	4	4	1
Yrs in herd -- repl females (Max = 4)	2	2	2	2	4	4	1
Yrs in herd -- young males (Max = 4)	1	2	2	2	2	2	1.5
Yrs in herd -- young females (Max = 4)	1	2	2	2	2	2	1.5
Yrs to slaughter for slaughterstk (Max = 4)	N/A	N/A	N/A	N/A	N/A	N/A	1

What information is needed

Annual Mortality Rates:

The annual mortality rates account for natural deaths in each animal category. Also included are the culling rates for adult male and female animals.

How to enter the information

⇒ Enter the Annual Mortality Rates (see table below). Ignore any columns representing sectors with no production. This table accounts for natural deaths and culling of herds. Reliable mortality rate data can be difficult to collect. An effort should be made to get a set of estimates that is as representative as possible.

	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All
Annual Mortality Rates							
Annual death rate -- adult males	2.0%	4.0%	4.0%	4.0%	4.0%	4.0%	2.0%
Annual death rate -- adult females	2.0%	4.0%	4.0%	4.0%	4.0%	4.0%	2.0%
Annual death rate -- repl males	2.0%	4.0%	4.0%	4.0%	4.0%	4.0%	2.0%
Annual death rate -- repl females	2.0%	4.0%	4.0%	4.0%	4.0%	4.0%	2.0%
Annual death rate -- young males	5.0%	10.0%	10.0%	10.0%	10.0%	10.0%	5.0%
Annual death rate -- young females	5.0%	10.0%	10.0%	10.0%	5.0%	5.0%	5.0%
Adult Male Cull Rate	2.0%	2.0%	2.0%	2.0%	0.0%	1.0%	10.0%
Adult Female Cull Rate	15.0%	5.0%	5.0%	5.0%	0.0%	1.0%	10.0%
Annual death rate -- slaughter stock	N/A	N/A	N/A	N/A	N/A	N/A	1.0%

What information is needed

Live Weight:

LAM uses the animal's live weight, which is much greater that the carcass weight, to help determine feed consumption and growth rates.

How to enter the information

- Move to the **Methane Characteristics Sheet** by clicking on the labeled button. On this sheet:

Enter the animal's live weight in the weight column (see following table). Ignore any rows representing sectors with zero production. Note the different weights for the dairy and meat sectors.

What information is needed

Feeding Situation:

The options for feeding situations are given below the Methane Characteristics Table. The feeding situation indicates how much energy the animals use to get their food.

How to enter the information

⇒ Enter the feeding situation using the column labeled "Feeding Situation (1 - 3 below)" (or "above" in Quattro Pro version). Ignore any rows representing sectors with zero production. Use the table of feeding situation choices given in the model below the data entry field to find the number that represents the correct feeding situation (In the Quattro Pro version this table is above). The feeding situations for the animals in the Topi Region are given in the following table.

What information is needed

Feed Digestibility:

Feed digestibility indicates how much of the feed energy is available to the animal. Common feed digestibilities for cattle range from 50% to 60% for crop by-products and rangelands; 60% to 70% for good pastures, good preserved forages, and grain supplemented diets; and 75% to 85% for high quality feedlot grain diets.

How to enter the information

⇒ Enter the feed digestibility percentage for each animal type of each sector. Ignore any rows representing sectors with zero production. Note the different digestibilities for each animal type of all sectors. The feed digestibilities for the animals in the Topi Region are given in the following table.

What information is needed

Methane Conversion Rates:

The methane conversion rate is the percent of feed energy converted to methane. This varies with the type and quality of feed. The IPCC/OECD Emissions Inventory Guidelines provide "standard assumptions" to use for this factor.

How to enter the information

⇒ Enter the methane conversion rate using the column labeled "Methane Conversion (1-8 below)" (or "above" in Quattro Pro version). Ignore any rows representing sectors with zero production. Use the table of methane conversion choices given in the model below the data entry field to find the number that represents the correct methane emission rate (In the Quattro Pro version this table is above). The methane conversion rates for the animal types in Topi Region are given in the following table. For example, the conversion rate for an urban adult male dairy animal is 7%. The table in LAM tells us that a conversion rate of 7% ("poor quality") corresponds to the number 3. So we will enter the number 3 for that row. (You may edit the methane conversion rate table to assign alternative values. This may be required to match the inputs shown in this tutorial.)

We have now finished entering the calibration information into LAM. To run the model and move to the **Results Sheet**, click the Run button. This sheet displays details about the livestock herds in each sector and estimates the emissions by sector and per unit product. Note that sectors designated as producing zero percent of the product emit no emissions and have herd sizes of zero. The model estimates are shown in the following tables.

Minister Dorje should verify at this time that the herd information is accurate. The herd numbers by sector and category of animal should be compared to the data he collected earlier. If the herd numbers do not closely represent actual herd numbers, inputs such as milk per lactation, intercalving interval, mortality rates, culling rates, carcass weights, and maximum years spent in each developmental stage should be reevaluated. This will calibrate the model to the production practices of the Topi Region. Once the model is calibrated, the spreadsheet should be saved under a new name, such as "CALIB01.XLS" (or "CALIB01.WB1") to save the calibration settings.

As shown in the table below, the total herd size is 62,700. The three dairy sectors have populations of 2,500, 9,100, and 8,200 respectively, for a total dairy population of 19,700. Total methane emissions are estimated as 3,235 tons/year.

Sector	Sector Name	Animal Type	Methane Emissions (kg/hd/yr)	Weight (kg)	Feeding Situation (1-3 below)	Feeding Situation Selected	Feed Digest (%)	Methane Conversion (1-8 below)	Methane Conversion Selected
Milk_1	Urban	Adult Males	90.8	500	1	Stall Fed	55	3	7.0%
Milk_1	Urban	Adult Females	80.2	400	1	Stall Fed	60	1	6.0%
Milk_1	Urban	Repl Males	51.9	300	1	Stall Fed	55	3	7.0%
Milk_1	Urban	Repl Females	42.9	250	1	Stall Fed	55	3	7.0%
Milk_1	Urban	Young Males	12.9	200	1	Stall Fed	65	6	3.0%
Milk_1	Urban	Young Females	11.4	200	1	Stall Fed	65	6	3.0%
Milk_2	Rural-Low	Adult Males	83.9	450	1	Stall Fed	55	3	7.0%
Milk_2	Rural-Low	Adult Females	65.8	375	1	Stall Fed	55	3	7.0%
Milk_2	Rural-Low	Repl Males	48.8	300	1	Stall Fed	55	3	7.0%
Milk_2	Rural-Low	Repl Females	41.5	250	1	Stall Fed	55	3	7.0%
Milk_2	Rural-Low	Young Males	11.4	200	1	Stall Fed	65	6	3.0%
Milk_2	Rural-Low	Young Females	10.7	200	1	Stall Fed	65	6	3.0%
Milk_3	Rural-Hills	Adult Males	93.1	450	2	Pasture/Range	55	3	7.0%
Milk_3	Rural-Hills	Adult Females	75.5	375	2	Pasture/Range	55	3	7.0%
Milk_3	Rural-Hills	Repl Males	55.6	300	2	Pasture/Range	55	3	7.0%
Milk_3	Rural-Hills	Repl Females	47.4	250	2	Pasture/Range	55	3	7.0%
Milk_3	Rural-Hills	Young Males	13.1	200	2	Pasture/Range	65	6	3.0%
Milk_3	Rural-Hills	Young Females	12.4	200	2	Pasture/Range	65	6	3.0%
Milk_4 Sector omitted from this exhibit									
Draft_1	Buffalo	Adult Males	78.3	400	1	Stall Fed	55	3	7.0%
Draft_1	Buffalo	Adult Females	58.6	300	1	Stall Fed	55	3	7.0%
Draft_1	Buffalo	Repl Males	38.8	250	1	Stall Fed	55	3	7.0%
Draft_1	Buffalo	Repl Females	26.9	150	1	Stall Fed	55	3	7.0%
Draft_1	Buffalo	Young Males	7.6	100	1	Stall Fed	65	6	3.0%
Draft_1	Buffalo	Young Females	5.5	75	1	Stall Fed	65	6	3.0%
Draft_2 Sector omitted from this exhibit									
Meat	All	Adult Males	93.1	450	2	Pasture/Range	55	3	7.0%
Meat	All	Adult Females	84.8	375	2	Pasture/Range	55	3	7.0%
Meat	All	Repl Males	65.2	300	2	Pasture/Range	55	3	7.0%
Meat	All	Repl Females	55.6	300	2	Pasture/Range	55	3	7.0%
Meat	All	Young Males	13.6	200	2	Pasture/Rang	65	6	3.0%

						e			
Meat	All	Young Females	13.6	200	2	Pasture/Range	65	6	3.0%
Meat	All	Male Slaught	81.3	500	1	Stall Fed	60	1	6.0%
Meat	All	Female Slaught	69.5	450	1	Stall Fed	60	1	6.0%

Results by Sector Calibration Case	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All	Total
Milk Production (1000 tons/yr)	3.8	2.9	2.9	0.0	0.4	0.0	0.0	10.0
Draft Production (1000 Head)	0.1	0.5	0.4	0.0	8.8	0.0	0.1	10.0
Meat Production (1000 tons/yr)	0.0	0.1	0.1	0.0	0.2	0.0	1.0	1.5
Methane Emissions (tons/yr)	154	488	499	0	1,321	0	773	3,235

Detailed Results by Sector Calibration Case	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All	Total
Total Herd (1000)	2.5	9.1	8.2	0.0	25.3	0.0	17.7	62.7
Bulls (1000)	0.1	0.5	0.5	0.0	8.5	0.0	0.2	9.7
Cows (1000)	1.4	5.2	4.7	0.0	6.5	0.0	2.4	20.1
Male Replacements (1000)	0.0	0.2	0.2	0.0	4.5	0.0	0.0	4.9
Female Replacements (1000)	0.6	1.9	1.7	0.0	3.4	0.0	0.5	8.1
Male Young (1000)	0.0	0.1	0.1	0.0	1.5	0.0	6.2	7.9
Female Young (1000)	0.3	1.2	1.1	0.0	1.0	0.0	3.3	6.9
Male Slaughters (1000)	NA	NA	NA	NA	NA	NA	3.8	3.8
Female Slaughters (1000)	NA	NA	NA	NA	NA	NA	1.3	1.3
Extra Young - Male (1000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Extra Young - Female (1000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Milk (1000 tons/yr)	3.8	2.9	2.9	0.0	0.4	0.0	0.0	10.0
Meat (1000 tons/yr)	0.0	0.1	0.1	0.0	0.2	0.0	1.0	1.5
Draft Male (1000)	0.1	0.5	0.4	0.0	8.0	0.0	0.1	9.2
Draft Female (1000)	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.8
Total Draft (1000)	0.1	0.5	0.4	0.0	8.8	0.0	0.1	10.0

Emissions per unit product Calibration Case	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All
CH4/Milk (g/kg)	40.12	169.28	173.36	0.00	NA	NA	NA
CH4/Draft (kg/Head)	NA	NA	NA	NA	149.35	0.00	NA
CH4/Meat (g/kg)	NA	NA	NA	NA	NA	NA	752.11

Evaluate the Proposed Dairy Improvement Program

Minister Dorje wants to examine the effects of his dairy improvement program on potential herd size and methane emissions in 2010. Before starting with the analysis, Minister Dorje confers with dairy industry experts to assemble information describing the potential impacts of the dairy program, as well as anticipated production conditions in the absence of any intervention. This information is summarized in the table below.

As shown in the table, production is expected to increase slightly by 2010 in the absence of the program as the result of increased herd size. With the program, the potential is for milk production to increase significantly (30%-50%) as the result of improved production practices and

feeding as well as expansion of the dairy industry. To use LAM to evaluate the impacts of the program on herd size and methane emissions we develop the following three scenarios:

1. *Baseline Practices Scenario:* This scenario will represent the baseline conditions in 2010 in the absence of the program.
2. *Intervention Scenario:* This scenario will represent the improved production practices, but will omit the anticipated increase in total production due to the program. This scenario will allow us to evaluate the impacts of the production improvements alone relative to the Baseline Scenario.
3. *Intervention Plus Increased Production Scenario:* This scenario will represent the full impacts of the program, including the anticipated increase in total production.

The inputs and results for each scenario are presented in turn below. Following the evaluation of each scenario, the model should be saved with a new name, so that at the end of the analysis you have separate models saved with the inputs and results for each scenario.

Summary of Dairy Improvement Program Impacts

No Dairy Improvement Program: In the absence of a dairy improvement program, production practices are anticipated to remain essentially unchanged. Animal management and feeding conditions will remain the same, as will milk production levels per cow. Due to increases in human population, the quantity of milk produced is expected to increase from 10,000 to 11,000 tons per year (10%) by 2010, and the meat production is expected to increase from 1,500 to 1,600 tons per year (about 7%). These increases are expected to be achieved by increasing the size of the herd. No change in draft power requirements are anticipated despite the population growth.

With Dairy Improvement Program: The program is expected to improve the nutrition of the dairy cows so that they produce more milk per lactation and they reduce the time interval between lactations. Additionally, as the result of improved nutrition, the young animals and replacements in the herd are expected to mature more quickly, reducing the time required before they can produce milk. While the impacts of the program are uncertain, estimates of potential impacts based on reviews of similar programs elsewhere include the following:

- milk production per cow per lactation will increase 25-30%
- length of lactation will increase slightly
- intercalving interval will decrease to about a year in the urban areas and to about 1.5 years in the other areas
- young animals will mature about 1 year faster in the non-urban areas, and urban replacement animals will mature about 1 year faster
- feed digestibility will increase by about 5% for the replacements and mature animals

In addition to these changes in production characteristics, estimates are that total milk production in the region will likely increase as the result of the intervention. While a baseline increase of 1,000 tons to 11,000 tons is expected in the absence of the program, the program is projected to increase production by an additional 30% to 50%. This large increase is anticipated as the result of increased production per cow, but also as the result of expansion of the dairy industry in response to improved economic return from dairying activities. To be conservative, the total production increase is assumed to be 30% or 3,300 tons, to result in a total production of 14,300 tons in 2010.

Baseline Scenario

What information is needed

Target Production Levels:
As population rises in the Topi Region and Mitocha's economy develops, Minister Dorje predicts that production of meat and milk will increase. However, he does not expect that significantly more land will be cultivated in this region, and some technical advances will occur, so the use of draft animals will probably stay constant.

How to enter the information

- In the LAM **Targets Sheet**,
  - ⇒ Enter future production levels in the Production Target Table (see table below). Topi Region will produce 11,000 metric tons of milk, 1,600 metric tons of meat, and has 10,000 working draft animals.

Product	Target
Milk Production (1000 tons/yr)	11.0
Draft Production (1000 Head)	10.0
Meat Production (1000 tons/yr)	1.6

Because we are assuming no production practice changes, no other new data needs to be entered for the Baseline Scenario. To run the model and move to the **Results Sheet**, click the Run button. Remember to save the model with a new name, such as "BASE01.XLS." The baseline estimated emissions are shown in the following tables.

As shown in the tables, the total herd size increases to about 65,500 head from 62,700 head in the calibration case. The milk herd and meat herd increase in size in response to the projected increases in production. The draft herd declines slightly in size because the milk and meat herds are producing slightly more draft power as the result of their increased size. Because total draft power requirements are estimated to remain unchanged, the increases in the milk and meat herd draft power supply are offset by reductions in the size of the draft herd.

Overall, methane emissions are estimated to increase from 3,235 tons/year in the calibration scenario to 3,381 tons/year in the Baseline Scenario. This is an increase of about 5%. Emissions per unit of milk production remain unchanged because production practices are projected to remain unchanged from the calibration scenario.

Results by Sector **Baseline Scenario**	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All	Total
Milk Production (1000 tons/yr)	4.2	3.2	3.2	0.0	0.4	0.0	0.0	11.0
Draft Production (1000 Head)	0.1	0.5	0.5	0.0	8.7	0.0	0.1	10.0
Meat Production (1000 tons/yr)	0.1	0.1	0.1	0.0	0.2	0.0	1.1	1.6
Methane Emissions (tons/yr)	170	539	552	0	1,305	0	815	3,381

Detailed Results by Sector Baseline Scenario	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All	Total
Total Herd (1000)	2.8	10.1	9.0	0.0	24.9	0.0	18.7	65.5
Bulls (1000)	0.1	0.6	0.5	0.0	8.4	0.0	0.2	9.8
Cows (1000)	1.5	5.8	5.2	0.0	6.4	0.0	2.4	21.2
Male Replacements (1000)	0.0	0.2	0.2	0.0	4.4	0.0	0.0	4.8
Female Replacements (1000)	0.7	2.1	1.9	0.0	3.4	0.0	0.5	8.5
Male Young (1000)	0.0	0.1	0.1	0.0	1.5	0.0	6.7	8.4
Female Young (1000)	0.4	1.3	1.2	0.0	1.0	0.0	3.4	7.3
Male Slaughters (1000)	NA	NA	NA	NA	NA	NA	4.1	4.1
Female Slaughters (1000)	NA	NA	NA	NA	NA	NA	1.4	1.4
Extra Young - Male (1000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Extra Young - Female (1000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Milk (1000 tons/yr)	4.2	3.2	3.2	0.0	0.4	0.0	0.0	11.0
Meat (1000 tons/yr)	0.1	0.1	0.1	0.0	0.2	0.0	1.1	1.6
Draft Male (1000)	0.1	0.5	0.5	0.0	7.9	0.0	0.1	9.2
Draft Female (1000)	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.8
Total Draft (1000)	0.1	0.5	0.5	0.0	8.7	0.0	0.1	10.0

Emissions per unit product Baseline Scenario	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All
CH4/Milk (g/kg)	40.12	169.28	173.36	0.00	NA	NA	NA
CH4/Draft (kg/Head)	NA	NA	NA	NA	149.35	0.00	NA
CH4/Meat (g/kg)	NA	NA	NA	NA	NA	NA	739.83

Intervention Scenario

The purpose of the Intervention Scenario is to estimate what would happen with the implementation of the dairy improvement program, holding future production unchanged from projected levels. The impacts of the program are listed above, and are entered as follows.

What information is needed

Milk Production:

The dairy program will improve the health and nutrition of cows in each dairy sector. The resulting improvement in milk production is needed to calculate the program's impact on production and herd size.

How to enter the information

- Move to the **Production Characteristics Sheet** by clicking on the labeled button. On this sheet:
  - ⇒ Enter the new milk production data shown in the table below. Note the increases in milk production per lactation, increases in lengths of lactation, and reductions in intercalving interval in the three dairy sectors. The other sectors remain unchanged.

Intervention Scenario Changed values are shaded	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All
Cows: Milk Production							
Milk per lactation (tons)	4.40	1.30	1.40	1.00	0.90	0.90	1.74
Length of lactation (days)	305	280	290	305	200	200	200
Intercalving interval (days)	390	540	500	365	600	600	365
Percent of Cows that are Bred	100.0%	100.0%	100.0%	100.0%	75.0%	50.0%	90.0%
Percent of milk produced for target	100.0%	100.0%	100.0%	100.0%	15.0%	0.0%	0.0%

Note: A non-zero value for "Milk per lactation" must be entered for each sector, even if that sector has a milk target of zero.

What information is needed

Maximum Years in the Herd:

Improved health and nutrition will speed the growth of animals in the dairy sectors. This improvement is reflected by reducing the time spent as young and replacements.

How to enter the information

⇒ Enter the number of years in the herd shown in the following table. Note the improvements in the dairy sector characteristics as growth rate increases.

Intervention Scenario Changed values are shaded	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All
Maximum Years in the Herd: Adults, Replacements, Young							
Yrs in herd -- adult males (Max = 10)	8	8	8	8	10	10	8
Yrs in herd -- adult females (Max = 10)	8	8	8	8	10	10	8
Yrs in herd -- repl males (Max = 4)	1	2	2	2	4	4	1
Yrs in herd -- repl females (Max = 4)	1	2	2	2	4	4	1
Yrs in herd -- young males (Max = 4)	1	1	1	2	2	2	1.5
Yrs in herd -- young females (Max = 4)	1	1	1	2	2	2	1.5
Yrs to slaughter for slaughterstk (Max = 4)	N/A	N/A	N/A	N/A	N/A	N/A	1

What information is needed

Live Weight:

Some programs may significantly affect the animal's weight. However, in this example we will leave the weights unchanged.

How to enter the information

- Move to the **Methane Characteristics Sheet** by clicking on the labeled button. On this sheet:

  ⇒ Leave Live Weight values unchanged.

What information is needed

Feeding Situation:

Some programs may involve changes in the feeding situation of some sectors. In this example, the feeding situations are unchanged.

How to enter the information

⇒ Leave Feeding Situation values unchanged

What information is needed

Feed Digestibility:

Feed digestibility will increase by 5% as dairy animals are fed higher quality or better prepared feeds as part of the dairy improvement program.

How to enter the information

⇒ Enter the feed digestibility estimates for each animal type of each sector shown in the following table. Note the improved digestibilities for the replacement and mature animals in the dairy sectors.

What information is needed

Methane Conversion Rates:

The methane conversion rate could be decreased if a program significantly changed the quality or type of feed. For this example, we will leave the conversion rates unchanged, which is a conservative assumption.

How to enter the information

⇒ Leave Methane Conversion Rate values unchanged.

We have now finished entering the Intervention Scenario information into the model. To run the model and move to the **Results Sheet**, click the Run button. Remember to save the model with a new name, such as "INTERV01.XLS." The estimated emissions for 2010 after the program intervention improvements are made are shown below.

As shown below, the herd size declines with the improved production practices. The total dairy herd declines to 13,300 from 21,900 in the Baseline Scenario. This large reduction is estimated because production per cow improves significantly while total milk production is assumed to remain unchanged from the original estimate for 2010. Also shown in the table is that the herd size for draft and meat animals is estimated to increase relative to the Baseline Scenario. This increase is estimated because the meat and draft power originating in the dairy sector declines with the reduction in the dairy herd size. In particular, the number of calves transferred from the dairy sector to the meat sector declines substantially, resulting in an increase in the number of cows in the meat sector. As a result the herd sizes for the draft and meat sectors must increase.

The overall impact of the interventions is a reduction in estimated methane emissions of nearly 10%, from 3,381 tons/year to 3,089 tons/year. The overall herd structure is changed, and the total amount of production is increased.

As discussed above, it may be unrealistic to expect total milk production to remain unchanged following the introduction of the dairy program. The next scenario examines the implications of a 30% increase in milk production that is estimated to occur as the result of the dairy program.

Intervention Scenario (Changed values are shaded)

Sector	Sector Name	Animal Type	Methane Emissions (kg/hd/yr)	Weight (kg)	Feeding Situation (1-3 below)	Feeding Situation Selected	Feed Digest (%)	Methane Conversion (1-8 below)	Methane Conversion Selected
Milk_1	Urban	Adult Males	90.8	500	1	Stall Fed	60	3	7.0%
Milk_1	Urban	Adult Females	80.2	400	1	Stall Fed	65	1	6.0%
Milk_1	Urban	Repl Males	51.9	300	1	Stall Fed	60	3	7.0%
Milk_1	Urban	Repl Females	42.9	250	1	Stall Fed	60	3	7.0%
Milk_1	Urban	Young Males	12.9	200	1	Stall Fed	65	6	3.0%
Milk_1	Urban	Young Females	11.4	200	1	Stall Fed	65	6	3.0%
Milk_2	Rural-Low	Adult Males	83.9	450	1	Stall Fed	60	3	7.0%
Milk_2	Rural-Low	Adult Females	65.8	375	1	Stall Fed	60	3	7.0%
Milk_2	Rural-Low	Repl Males	48.8	300	1	Stall Fed	60	3	7.0%
Milk_2	Rural-Low	Repl Females	41.5	250	1	Stall Fed	60	3	7.0%
Milk_2	Rural-Low	Young Males	11.4	200	1	Stall Fed	65	6	3.0%
Milk_2	Rural-Low	Young Females	10.7	200	1	Stall Fed	65	6	3.0%
Milk_3	Rural-Hills	Adult Males	93.1	450	2	Pasture/Range	60	3	7.0%
Milk_3	Rural-Hills	Adult Females	75.5	375	2	Pasture/Range	60	3	7.0%
Milk_3	Rural-Hills	Repl Males	55.6	300	2	Pasture/Range	60	3	7.0%
Milk_3	Rural-Hills	Repl Females	47.4	250	2	Pasture/Range	60	3	7.0%
Milk_3	Rural-Hills	Young Males	13.1	200	2	Pasture/Range	65	6	3.0%
Milk_3	Rural-Hills	Young Females	12.4	200	2	Pasture/Range	65	6	3.0%
Milk_4 Sector omitted from this exhibit									
Draft_1	Buffalo	Adult Males	78.3	400	1	Stall Fed	55	3	7.0%
Draft_1	Buffalo	Adult Females	58.6	300	1	Stall Fed	55	3	7.0%
Draft_1	Buffalo	Repl Males	38.8	250	1	Stall Fed	55	3	7.0%
Draft_1	Buffalo	Repl Females	26.9	150	1	Stall Fed	55	3	7.0%
Draft_1	Buffalo	Young Males	7.6	100	1	Stall Fed	65	6	3.0%
Draft_1	Buffalo	Young Females	5.5	75	1	Stall Fed	65	6	3.0%
Draft_2 Sector omitted from this exhibit									
Meat	All	Adult Males	93.1	450	2	Pasture/Range	55	3	7.0%
Meat	All	Adult Females	84.8	375	2	Pasture/Range	55	3	7.0%
Meat	All	Repl Males	65.2	300	2	Pasture/Range	55	3	7.0%
Meat	All	Repl Females	55.6	300	2	Pasture/Range	55	3	7.0%
Meat	All	Young Males	13.6	200	2	Pasture/Range	65	6	3.0%
Meat	All	Young Females	13.6	200	2	Pasture/Range	65	6	3.0%

Meat	All	Male Slaught	81.3	500	1	Stall Fed	60	1	6.0%
Meat	All	Female Slaught	69.5	450	1	Stall Fed	60	1	6.0%

Results by Sector								
Intervention Scenario	Milk_1	Milk_2	Milk_3	Milk_4	Draft_1	Draft_2	Meat	
	Urban	Rural-Low	Rural-Hills	Blank	Buffalo	Blank	All	Total
Milk Production (1000 tons/yr)	4.2	3.2	3.2	0.0	0.4	0.0	0.0	11.0
Draft Production (1000 Head)	0.1	0.3	0.3	0.0	9.1	0.0	0.2	10.0
Meat Production (1000 tons/yr)	0.0	0.1	0.1	0.0	0.2	0.0	1.2	1.6
Methane Emissions (tons/yr)	106	315	308	0	1,356	0	1,004	3,089

Detailed Results by Sector								
Intervention Scenario	Milk_1	Milk_2	Milk_3	Milk_4	Draft_1	Draft_2	Meat	
	Urban	Rural-Low	Rural-Hills	Blank	Buffalo	Blank	All	Total
Total Herd (1000)	1.7	6.2	5.4	0.0	25.9	0.0	22.3	61.5
Bulls (1000)	0.1	0.4	0.3	0.0	8.7	0.0	0.3	9.7
Cows (1000)	1.0	3.6	3.1	0.0	6.6	0.0	3.8	18.1
Male Replacements (1000)	0.0	0.1	0.1	0.0	4.6	0.0	0.1	4.9
Female Replacements (1000)	0.2	1.3	1.1	0.0	3.5	0.0	0.7	6.9
Male Young (1000)	0.0	0.1	0.1	0.0	1.5	0.0	6.6	8.2
Female Young (1000)	0.3	0.8	0.7	0.0	1.0	0.0	5.0	7.7
Male Slaughters (1000)	NA	NA	NA	NA	NA	NA	4.0	4.0
Female Slaughters (1000)	NA	NA	NA	NA	NA	NA	2.0	2.0
Extra Young - Male (1000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Extra Young - Female (1000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Milk (1000 tons/yr)	4.2	3.2	3.2	0.0	0.4	0.0	0.0	11.0
Meat (1000 tons/yr)	0.0	0.1	0.1	0.0	0.2	0.0	1.2	1.6
Draft Male (1000)	0.1	0.3	0.3	0.0	8.2	0.0	0.2	9.2
Draft Female (1000)	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.8
Total Draft (1000)	0.1	0.3	0.3	0.0	9.1	0.0	0.2	10.0

Emissions per unit product							
Intervention Scenario	Milk_1	Milk_2	Milk_3	Milk_4	Draft_1	Draft_2	Meat
	Urban	Rural-Low	Rural-Hills	Blank	Buffalo	Blank	All
CH4/Milk (g/kg)	25.01	99.15	97.06	0.00	NA	NA	NA
CH4/Draft (kg/Head)	NA	NA	NA	NA	149.35	0.00	NA
CH4/Meat (g/kg)	NA	NA	NA	NA	NA	NA	833.67

Intervention Plus Increased Production Scenario

By improving production practices in the dairy sector, the dairy program may increase production by 30-50%. This scenario builds on the Intervention Scenario by increasing the target level of milk production by 30%. For simplicity, it is assumed that the distribution of milk production among the three milk herds remains unchanged. Enter the following information into the model:

What information is needed

Target Production Levels:

Because of program improvements, the dairy sectors can increase production so the Target Milk Production level will increase.

How to enter the information

- In the LAM **Targets Sheet**,
  - ⇒ Enter increased future milk production levels in the Production Target Table as shown below. With the intervention, the Topi Region could increase milk production to 14,300 metric tons of milk.

Product	Target
Milk Production (1000 tons/yr)	14.3
Draft Production (1000 Head)	10.0
Meat Production (1000 tons/yr)	1.6

To run the model with the higher milk production target and move to the **Results Sheet**, click the Run button. Remember to save the model with a new name, such as "INPLUS01.XLS." The new estimated emissions are shown below.

As shown in the tables, the total cattle population is estimated to be 61,000. The milk herd is estimated to be 17,400, an increase of 4,100 from the Intervention Scenario. However, this still represents a reduction of about 4,500 from the Baseline Scenario, despite the increase in production. As the dairy production targets and herd sizes increase from the Intervention Scenario, the meat production from the dairy population increases, allowing the size of the meat herd to decline significantly. In particular, the dairy sectors can transfer increased numbers of calves to the meat sector for subsequent meat production.

With the increased production of milk, the overall methane emissions decline slightly to 3,038 tons/year. The total declines because increased meat and draft production in the dairy sector offsets emissions from the draft and meat sectors.

Results by Sector **Intervention Plus Increase**	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All	Total
Milk Production (1000 tons/yr)	5.6	4.2	4.2	0.0	0.4	0.0	0.0	14.3
Draft Production (1000 Head)	0.1	0.4	0.4	0.0	9.0	0.0	0.1	10.0
Meat Production (1000 tons/yr)	0.0	0.1	0.1	0.0	0.2	0.0	1.1	1.6
Methane Emissions (tons/yr)	139	413	405	0	1,344	0	737	3,038

Detailed Results by Sector Intervention Plus Increase	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All	Total
Total Herd (1000)	2.2	8.2	7.0	0.0	25.7	0.0	17.9	61.0
Bulls (1000)	0.1	0.5	0.4	0.0	8.6	0.0	0.1	9.7
Cows (1000)	1.3	4.7	4.1	0.0	6.6	0.0	1.4	18.2
Male Replacements (1000)	0.0	0.2	0.1	0.0	4.5	0.0	0.0	4.9
Female Replacements (1000)	0.3	1.7	1.5	0.0	3.5	0.0	0.3	7.3
Male Young (1000)	0.0	0.1	0.1	0.0	1.5	0.0	6.3	8.0
Female Young (1000)	0.3	1.0	0.9	0.0	1.0	0.0	4.0	7.2
Male Slaughters (1000)	NA	NA	NA	NA	NA	NA	3.8	3.8
Female Slaughters (1000)	NA	NA	NA	NA	NA	NA	2.0	2.0
Extra Young - Male (1000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Extra Young - Female (1000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Milk (1000 tons/yr)	5.6	4.2	4.2	0.0	0.4	0.0	0.0	14.3
Meat (1000 tons/yr)	0.0	0.1	0.1	0.0	0.2	0.0	1.1	1.6
Draft Male (1000)	0.1	0.4	0.4	0.0	8.2	0.0	0.1	9.2
Draft Female (1000)	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.8
Total Draft (1000)	0.1	0.4	0.4	0.0	9.0	0.0	0.1	10.0

Emissions per unit product Intervention Plus Increase	Milk_1 Urban	Milk_2 Rural-Low	Milk_3 Rural-Hills	Milk_4 Blank	Draft_1 Buffalo	Draft_2 Blank	Meat All
CH4/Milk (g/kg)	25.01	99.15	97.06	0.00	NA	NA	NA
CH4/Draft (kg/Head)	NA	NA	NA	NA	149.35	0.00	NA
CH4/Meat (g/kg)	NA	NA	NA	NA	NA	NA	642.27

Mitocha Tutorial Summary Results

The LAM analysis shows that the dairy improvement program has the potential to increase milk production substantially and reduce methane emissions by nearly 10%. The following table shows the estimates of the livestock populations under each scenario. Under Baseline conditions, the total herd is expected to increase from the current Calibration conditions. With the Intervention Scenario, the total herd size declines, primarily because of the sharp decline in the dairy sector. With increased milk production, the size of the dairy herd increases from the Intervention Scenario, and the total herd size declines slightly.

	Herd Size (000)				Methane
Scenario	**Dairy**	**Draft**	**Meat**	**Total**	**(tons/yr)**
Calibration Scenario	19.8	25.3	17.7	62.7	3,235
Baseline Scenario	21.9	24.9	18.7	65.5	3,381
Intervention Scenario	13.3	25.9	22.3	61.5	3,089
Intervention Plus Increased Production	17.4	25.7	17.9	61.0	3,038

Total methane emissions decline in the Intervention Scenario because methane emissions per unit of milk produced declines substantially. Relative to current production conditions, the

methane emissions per unit of milk produced decline by about 45% overall with the implementation of the dairy improvement program.

The analysis also demonstrates the linkages among the different livestock sectors. In particular, the dairy sector is an important source of calves for meat production. Reductions in the size of the dairy herd can reduce its contribution to meat production, requiring a compensating increase in the size of the herd used to produce meat. These linkages underscore the importance of analyzing the entire livestock industry.

Additional Exercises

To explore further how to use LAM to assess options for improving livestock production and reducing methane emissions, the following additional exercises are recommended. These exercises build off of the Mitocha tutorial.

1. *Increased Milk Production.* It may be unrealistic to expect the sizes of the dairy herds to decline with the implementation of the dairy improvement program. What would happen if total milk production were to increase 50% to 16,500 tons per year along with the intervention? What would happen to the size of the dairy herd? What would happen to the estimate of methane emissions?
2. *Re-allocation of the Milk Target.* Under all scenarios the rural dairy sectors have higher emissions per unit of milk produced than the urban dairies. What would happen to the estimates of methane emissions if the milk target were re-allocated so that the increases in milk production occurred only in the urban areas? What would happen to the cow populations in the rural areas?
3. *No Meat Production Target.* In many counties meat production from cattle is not permitted or is not a priority. How would the results of the analysis change if the meat target were set to zero? How would the intervention affect total methane emissions?